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# A Technique for Classifying Vehicular Targets as Either Frontal or Flank Views for Use in Range Estimation and Application of Lead Rules for the Bradley Fighting Vehicle

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Training Research Laboratory
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July 1988

United States Army
Research Institute for the Behavioral and Social Sciences

# U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

## A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

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In efforts to improve range estimation accuracy for the Bradley Fighting Vehicle, this report describes development of a technique to classify vehicular targets as either frontal or flank views and modification of a quick reference table to be used as a job performance aid. The target-view classification technique will allow more effective use of the quick reference table for range estimation, more accurate use of the ranging stadia on the auxiliary sight unit, and application of lead rules for engaging flank views of moving targets. The target-view classification technique and the modified quick reference table will be included in the BFV Gunnery field manual (FM 23-1).

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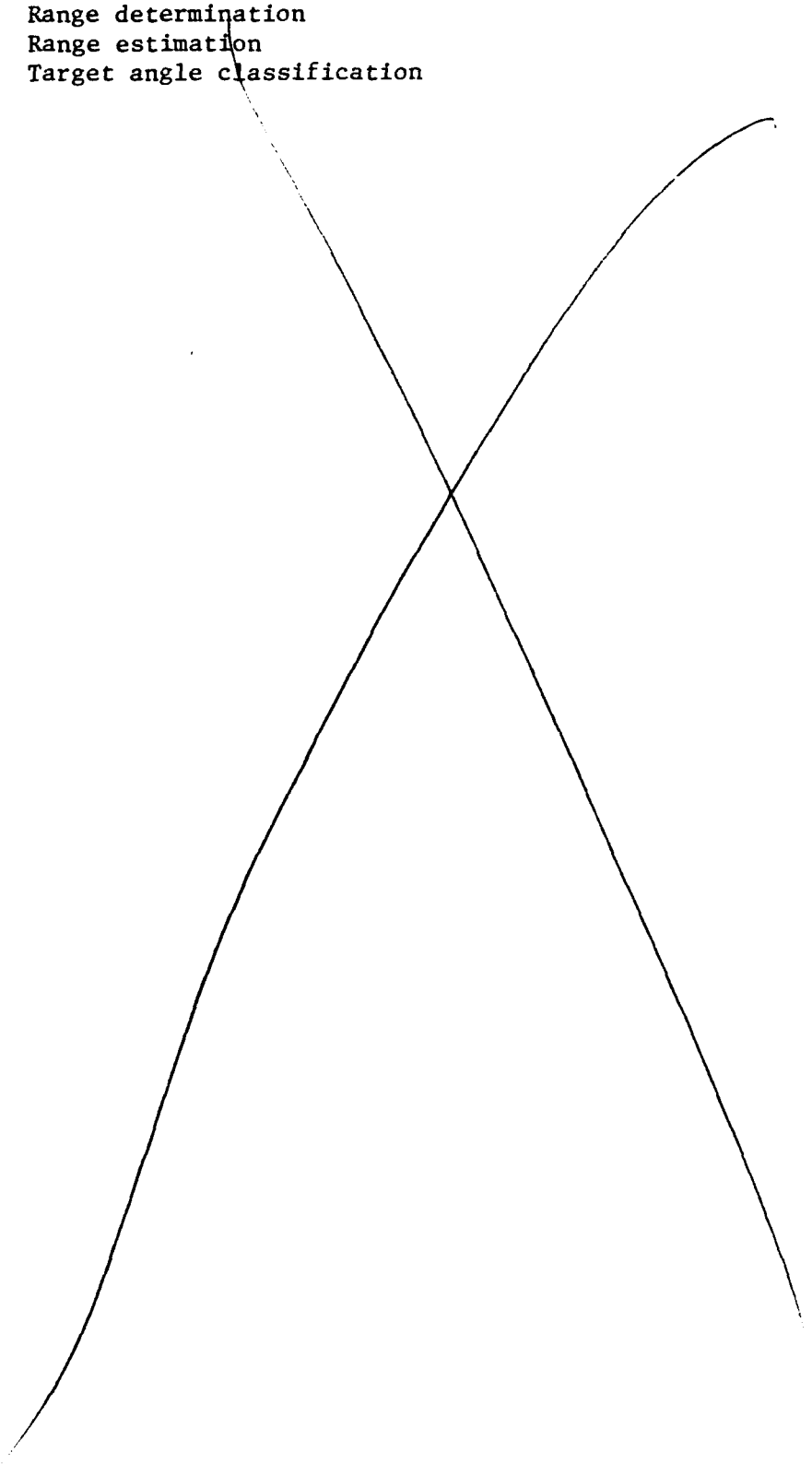

## FOREWORD

Since 1975 the Army Research Institute for the Behavioral and Social Sciences (ARI) has contributed to a program to define emerging problems and address critical issues affecting the Bradley Fighting Vehicle. Consistent with that program, this report describes a technique developed to classify vehicular targets as either frontal or flank views for purposes of range estimation and application of aiming rules. Also reported is an improved job performance aid, a quick reference table, for range estimation. The description of the developed/modified techniques and job performance aids provided in the "Summary and Conclusions" section is intended for gunnery literature developers for the BFV. The technically based "Procedure" and "Findings" sections are oriented to a scientific audience.

ARI's Fort Benning Field Unit, a division of the Training Research Laboratory, monitored this research. ARI's mission is to conduct research of training and training technology using infantry combat systems and problems as mediums. The research task that supports this mission is "Advanced Methods and Systems for Fighting Vehicle Training," is organized under the "Train the Force" program area. Sponsorship for this research is provided by a Memorandum of Understanding (effective 31 May 1983) between the U.S. Army Infantry School (USAIS), Training and Doctrine Command (TRADOC), Training Technology Agency, and ARI, which established how joint efforts to improve BFV tactical doctrine, unit, and gunnery training would proceed.

As a result of close cooperation and coordination with the BFV gunnery proponent of USAIS, the developed techniques and aids will be integrated into the BFV Gunnery field manual (FM 23-1).

A TECHNIQUE FOR CLASSIFYING VEHICULAR TARGETS AS EITHER FRONTAL OR FLANK VIEWS FOR USE IN RANGE ESTIMATION AND APPLICATION OF LEAD RULES FOR THE BRADLEY FIGHTING VEHICLE

## EXECUTIVE SUMMARY


Requirement:

One range estimation technique described in the Bradley Fighting Vehicle (BFV) Gunnery field manual (FM 23-1, 1986) requires the gunner to measure target width in mils using a reticle, classify the target view as frontal or flank, classify a vehicular target into one of three groups, and use a job performance aid called a quick reference table to estimate range. Analysis of this technique indicated requirements to develop a technique to classify a vehicular target as either frontal or flank and to improve and simplify the quick reference table.

Procedure:

Mathematical analysis determined relative changes in the apparent or visible width of a vehicle's side and front at oblique target angles as a means to classify any target as frontal or flank. Analysis also examined the relationship between target angle, range, and visible width in mils to develop modifications in the quick reference table that would improve its accuracy and ease of use.

Findings:

As the view of a vehicular target changes from a full-frontal exposure to a full-flank exposure, less of the front remains visible and more of the vehicle's side can be seen. A vehicular target can be classified as a frontal view if the front appears larger than the side and a flank view if the side appears larger than the front. For purposes of range estimation, the quick reference table was modified so that one target group represents the majority of vehicular targets engaged by the BFV.

Utilization of Findings:

The developed technique for classifying target view as either frontal or flank will allow (a) more effective use of the quick reference table for range estimation, (b) more accurate use of the ranging stadia on the auxiliary sight unit, and (c) application of lead rules for engaging flank views of moving targets. The modified quick reference table for range estimation will simplify and improve range estimation accuracy. The developed technique for classifying target view and the modified quick reference table will be included in the BFV Gunnery field manual (FM 23-1).

A TECHNIQUE FOR CLASSIFYING VEHICULAR TARGETS AS EITHER FRONTAL OR FLANK VIEWS FOR USE IN RANGE ESTIMATION AND APPLICATION OF LEAD RULES FOR THE BRADLEY FIGHTING VEHICLE

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# A TECHNIQUE FOR CLASSIFYING VEHICULAR TARGETS AS EITHER FRONTAL OR FLANK VIEWS FOR USE IN RANGE ESTIMATION AND APPLICATION OF LEAD RULES FOR THE BRADLEY FIGHTING VEHICLE

## Introduction

### Background

Since August, 1983, the Fort Benning Field Unit of the Army Research Institute (ARI) and its resident contractor, Litton Computer Systems, has conducted research to develop training and to improve operational effectiveness of the Bradley Fighting Vehicle (BFV) under all visibility conditions. A major emphasis was to develop techniques and procedures to improve gunnery performance with the 25-mm gun. Separate reports summarize the overall work efforts (Perkins, 1987; 1988b).

Two primary work areas in gunnery were range estimation and application of lead rules for engaging moving targets. These seemingly diverse tasks have the requirement to classify a target angle as either frontal or flank.

Two range-estimation techniques described in the BFV Gunnery field manual (FM 23-1, 1983; 1986) require target-angle classification. The auxiliary sight unit of the BFV has a stadia used to estimate range based on the width of the target. Range estimation for frontal and flank angles of the target requires different use of the stadia.

Another range estimation technique requires use of a reticle (i.e., from a sight or binoculars) to measure target width in mils. The WORM (width over range times mils) formula then can be used to estimate range if the height, width, or length of the target is known. In that the WORM formula and target dimensions are difficult to remember, the BFV Gunnery field manual includes a quick reference table for range estimation (see Figure 1). The table, which was developed based on the WORM formula, classifies targets into four groups according to size.

Classification of angle of approach is important when engaging moving targets with the 25-mm gun. Lead rules are applied on a target that is moving perpendicular to the line of fire, but not when the target is approaching or fleeing the BFV (FM 23-1, 1986).

### Problems

Training and illustrations on the previously cited range estimation techniques and aiming rules show either full-frontal or full-flank angles of the target. There are no recommended techniques for aiming and estimating range on oblique angles of the target.

The quick reference table for range estimation (see Figure 1) classifies targets by size. Of the three groups for vehicular targets, Groups I and II have very similar dimensions. Equally confusing to instructors is that the BMP, the primary target of the 25-mm gun, has target dimensions (2.94 meters wide and 6.74 meters long) that are between the dimensions given for Groups I

**NOTE: This table is a quick reference for determining the range of Threat vehicles at various ranges. The vehicles have been grouped and the sizes of the vehicles have been averaged.**

**GP 1 (BMP, BTR-152, BTR-60P, OT-62 & 64, MTLB & TAB 72)**

| | 6.5 | 6 | 5.5 | 5 | 4.5 | 4 | 3.5 | 3 | 2.5 | 2 | 1.5 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FLANK 7.0 METERS | 1000 | 1200 | 1200 | 1400 | 1600 | 1800 | 2000 | 2400 | 2800 | 3500 | 4700 | 7000 |
| FRONT 2.8 METERS | 0 | 0 | 0 | 0 | 0 | 0 | 800 | 1000 | 1200 | 1400 | 1800 | 2800 |

**GP II (T-72, T-64, T—62, T—55, T-54, PT-76, ZSU 23-4)**

| | 6.5 | 6 | 5.5 | 5 | 4.5 | 4 | 3.5 | 3 | 2.5 | 2 | 2.5 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FLANK 6.5 METERS | 1000 | 1000 | 1200 | 1200 | 1400 | 1600 | 1800 | 2200 | 3600 | 3300 | 4300 | 6500 |
| FRONT 3.35 METERS | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 1000 | 1200 | 1600 | 2200 | 3350 |

**GP III (BMD, BRDM)**

| | 6.5 | 6 | 5.5 | 5 | 4.5 | 4 | 3.5 | 3 | 2.5 | 2 | 1.5 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FLANK 5.5 METERS | 800 | 800 | 1000 | 1000 | 1200 | 1400 | 1600 | 1800 | 2200 | 2800 | 3650 | 5500 |
| FRONT 2.35 METERS | 0 | 0 | 0 | 0 | 0 | 0 | 600 | 800 | 1000 | 1200 | 1600 | 2400 |

**GP IV (HIND-D HELICOPTER)**

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FLANK 17.25 METERS | 1200 | 1200 | 1400 | 1400 | 1600 | 1800 | 2000 | 2200 | 2400 | 2800 | 3400 | 3800 |
| | 6.5 | 6 | 5.5 | 5 | 4.5 | 4 | 3.5 | 3 | 2.5 | 2 | 1.5 | 1 |
| FRONT 6.9 METERS | 1000 | 1200 | 1200 | 1400 | 1600 | 1800 | 2000 | 2400 | 2800 | 3400 | 4600 | 6900 |

Figure 1. Quick reference table for range estimation (FM 23-1, 1986, p. 4-9).

and II. Course instruction has been observed to indicate that the flank data for Groups I and II are reversed in the gunnery manual. Another problem with the current table is that a range of 0 meters is listed in certain portions of the table.

## Purpose

The primary research objectives were to:

- Develop a technique to classify all target angles as either frontal or flank views,
- Develop improved techniques to estimate range with (a) the stadia of the auxiliary sight unit and (b) reticles marked in mils,
- Modify the quick reference table to improve accuracy and ease of use,
- Develop guidelines to apply aiming rules based on the angle of the target.

The following provides a detailed description of the development of these techniques and job performance aids.

## A Technique to Classify Targets as Frontal or Flank Views

### Background

The objective was to develop a technique to classify all target angles as either frontal or flank thereby eliminating the need for a third category for oblique target angles. The following provides a technical description of the development of the target-angle classification technique.

### Procedure

Analysis distinguished between actual and visible dimensions of a vehicle's front and side. Actual dimensions (side and front) of a vehicular target are the same for all target angles while visible dimensions change with angle or orientation of the target to the observer. For the observer, only the side of a vehicular target is visible for a full-flank view while only the width or front of the vehicle is exposed for a full-frontal view. For oblique target views, portions of both the front and side of the target are visible (see Figure 2). The first phase of the analysis determined the visible size of the target's front and side for oblique target angles. This provided background information for development of a technique to classify oblique targets as either frontal or flank views.

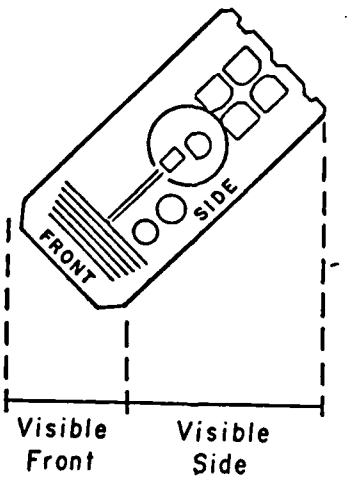



Figure 2. Illustration of actual and visible dimensions of a vehicle oriented at an oblique target angle.

Mathematical analysis determined the visible front and side dimensions of a BMP oriented at varied angles to the observer. A 0-degree angle exposes the vehicle's front while a 90-degree angle exposes the side. Calculation of visible dimensions was based on a BMP with front and side dimensions of 2.94

and 6.74 meters, respectively. Visible frontal size, flank size, and total width were calculated using Equations 1, 2, and 3.

visible front width (meters) = cos (angle) X actual width (meters) (1)

visible side width (meters) = sin (angle) X actual length (meters) (2)

visible total width (meters) = visible front width + visible side width (3)

Note that visible total width is the sum of the visible front and side widths.

## Findings

Table 1 indicates that the visible total width of the target is largest at an oblique angle of 65 degrees (7.35 meters wide), and not at a full-flank angle of 90 degrees (6.74 meters wide). At 45 degrees, the visible total width of a BMP is nearly identical to that of a 90-degree angle. Overall, the visible total width of a BMP is larger at angles between 45 and 90 degrees than it is at 90 degrees. An illustration of changes in visible total width of the target at varied target angles is presented in Figure 3.

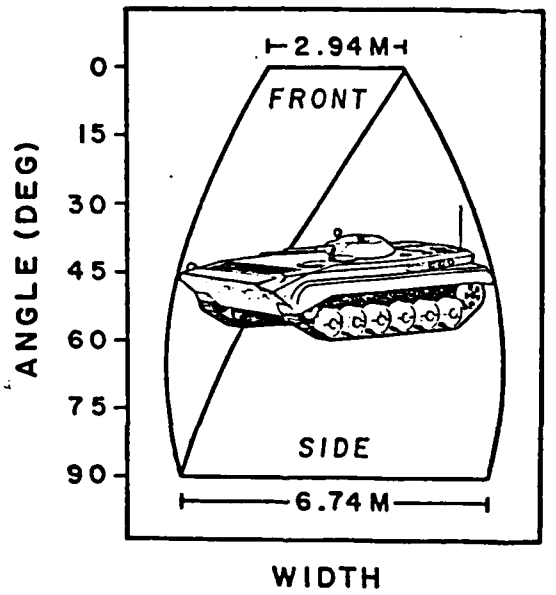



Figure 3. Amount of visible front and side portions of a BMP at varied angles.

At an angle of 24 degrees, the visible front and side widths were nearly identical; the angle in which these two dimensions are equal will be defined as the cross-over angle. The front of the vehicle appears larger than the side for target angles less than the cross-over angle; and for angles greater than this, the side of the vehicle appears larger than the front.

The cross-over angles also were determined for target types classified in the current quick reference table. These calculations were performed to determine the generality of data obtained during analysis of BMP data. The cross-over angles for Groups I, II, and III of the table were 22, 28, and 24

Table 1

Visible Width (m) of a BMP Oriented at Varied Angles

| Target angle (degrees) | Visible front width (m) | Visible side width (m) | Visible total width (m) |
|---|---|---|---|
| 0 (Front only) | 2.94 | 0.00 | 2.94 |
| 5 | 2.93 | 0.59 | 3.52 |
| 10 | 2.90 | 1.17 | 4.07 |
| 15 | 2.84 | 1.74 | 4.58 |
| 20 | 2.76 | 2.31 | 5.07 |
| 25 | 2.66 | 2.85 | 5.51 |
| 30 | 2.55 | 3.37 | 5.92 |
| 35 | 2.41 | 3.87 | 6.27 |
| 40 | 2.25 | 4.33 | 6.58 |
| 45 | 2.08 | 4.77 | 6.84 |
| 50 | 1.89 | 5.16 | 7.05 |
| 55 | 1.69 | 5.52 | 7.21 |
| 60 | 1.47 | 5.84 | 7.31 |
| 65 | 1.24 | 6.11 | 7.35 |
| 70 | 1.01 | 6.33 | 7.34 |
| 75 | 0.76 | 6.51 | 7.27 |
| 80 | 0.51 | 6.64 | 7.15 |
| 85 | 0.26 | 6.71 | 6.97 |
| 90 (Side only) | 0.00 | 6.74 | 6.74 |

degrees, respectively. Because of the minor differences in cross-over angle for the different groups, a representative cross-over angle for vehicular targets was selected to be 25 degrees.

## Summary and Conclusions

Analysis supports a simple, two-part rule for classifying a target as either a frontal or flank view. If the front appears larger than the side of the target, classify the target as a frontal view (see Figure 4). If the side appears larger than the front, classify it as a flank view. Use of this technique for classifying a target as either a frontal or flank view will be called the target-view or TV technique.

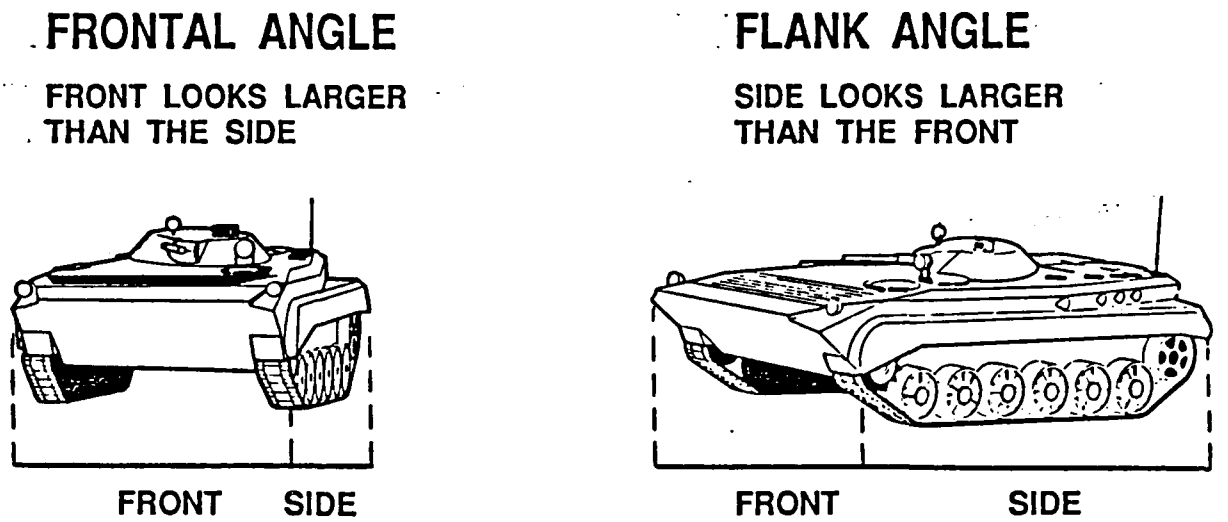



Figure 4. Classification of target angle.

## Range Estimation for Frontal and Flank Views of a Target

### Background

Use of reticles for range estimation requires information on actual size (e.g., meters) and visual size (e.g., mils) of the target. The actual target size used to determine range is either the front width (i.e., frontal view) or the length (i.e., flank view) of the target. Use of the front width or side width of the target can provide accurate range estimation when the target is at full-frontal (0-degree angle) and full-flank (90-degree angle) views, respectively. However, range estimation is complicated when the target is not a full-frontal or a full-flank view. For frontal and flank views of a target that are not at 0 and 90 degree angles, respectively, the primary questions are:

- Which dimension of the target best represents it size?
- What part of the target is measured with the reticle?

For example, a BMP at a 24-degree angle (frontal view) has a visible total width (5.43 meters) that is considerably larger than the actual front width (2.94 meters) of the vehicle. In this case, if range estimation was based on actual front width of the target combined with measurements of the visible total width (front plus side) of the target, then a 46% error in range estimation would occur.

The purpose of this analysis was to predict the relative accuracy of different techniques for estimating range for frontal and flank views of a target. Variations in the techniques were: (a) the actual size of the vehicle used to calculate range and (b) the part of the vehicle measured with the reticle.

Procedure

Analysis predicted the accuracy of different techniques for estimating range of targets classified as frontal and flank views using the TV-technique. For a BMP classified as a frontal angle, the three candidate techniques were:

- Measurement of the visible total width (front plus side) of a BMP and use of the actual front width (2.94 meters) of the vehicle,
- Measurement of only the visible front width of the BMP and use of the actual front width (2.94 meters) of the vehicle,
- Measurement of the visible total width (front plus side) of a BMP and use of the actual width of a BMP oriented at a 10-degree angle (4.07 meters, see Table 1).

Use of a BMP at a 10-degree target angle for the third alternative produces a target width that is about midway between the smallest (2.94 meters at 0 degrees) and the largest (5.43 meters at 24 degrees) actual total target width for angles classified as frontal.

For angles of a BMP classified as flank, the candidate techniques were:

- Measurement of the visible total width (front plus side) of the BMP and using the actual length (6.74 meters) of the vehicle,
- Measurement of the visible side width of the BMP and using the actual length (6.74 meters) of the vehicle.

Only the actual length of the vehicle was used in these alternative techniques because the length of a vehicle at a 90-degree angle (6.74 meters) is about midway between the smallest (5.60 meters at 26 degrees) and the largest (7.35 meters at 65 degrees) actual target sizes for angles classified as flank.

Analysis predicted the percentage of error in range estimation to a BMP at varied target angles using the following equation:

$$\text{predicted \% of error at a target angle} = \left[\frac{\text{representative target size}}{\text{target size at angle}} - 1\right] \times 100$$

The representative target size is that dimension of the target used to represent target size. The target size at angle is a function of both (a) the part of the target that is measured and (b) the visible width of that part at the angle of the target.

The accuracy standard was an error of no more than 10% (FM 23-1, 1986). The predicted error did not consider user and equipment related errors (e.g., insufficient level of magnification, failure to achieve a steady platform for measuring target size, less than optimal reticle design). These factors would undoubtedly contribute to error levels, however, the current analysis focused on the impact of technique on ranging accuracy.

## Findings

For frontal angles of a BMP, only one technique (see the first column of data in Table 2) produced ranging errors that were less than 10%. With this technique, only the visible front width of the target was measured and calculations of range were determined using the actual front width of the target. The other two techniques produced errors considerably higher than 10% for certain target angles.

For flank angles of a BMP (see Table 3), the technique of measuring the visible total width of the target and using the actual length of the target produced the better ranging accuracy. The greatest error for this technique was from 14 to 20% for target angles of 30 and 26 degrees, respectively. All other target angles had ranging errors less than 10%.

## Summary and Conclusions

When using a reticle of binoculars or an optical sight to estimate range, the following is recommended:

- Classify target angle as either frontal or flank using the TV technique (see Figure 4);
- For frontal angles, measure only the visible front of the target;
- For flank angles, measure the entire visible width (front plus side) of the target;
- Use the quick reference table to estimate range.

Figure 5 shows how the center cross of the integrated sight unit (ISU) can be used to measure target size in mils for frontal and flank angles of a BMP. Figure 6 illustrates the recommended technique for using the ranging stadia of the auxiliary sight unit. When estimating range to a frontal angle of a target, "choke" only the front portion of the target between the stadia lines. The entire target is choked for flank angles.

Table 2

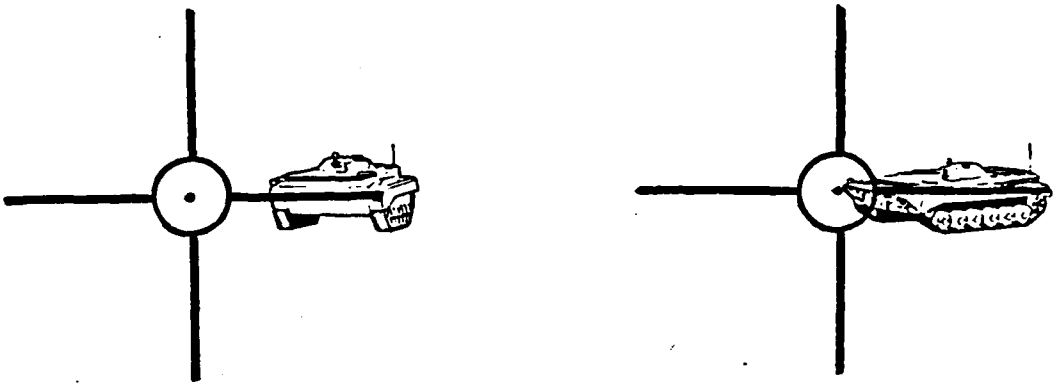
Predicted Percentage of Error in Range Estimation for Frontal Angles of a BMP

| | Technique (part of target measured-representative target size used) | | |
|---|---|---|---|
| Target angle | Front only-front (2.94 m) | Entire-front (2.94 m) | Entire-10 angle |
| 0 | 0 | 0 | 38 |
| 2 | 0 | -7 | 28 |
| 4 | 0 | -14 | 20 |
| 6 | 1 | -19 | 12 |
| 8 | 1 | -24 | 6 |
| 10 | 1 | -28 | 0 |
| 12 | 2 | -31 | -5 |
| 14 | 3 | -34 | -9 |
| 16 | 4 | -37 | -13 |
| 18 | 5 | -40 | -17 |
| 20 | 6 | -42 | -20 |
| 22 | 8 | -44 | -23 |
| 24 | 9 | -46 | -25 |

Table 3

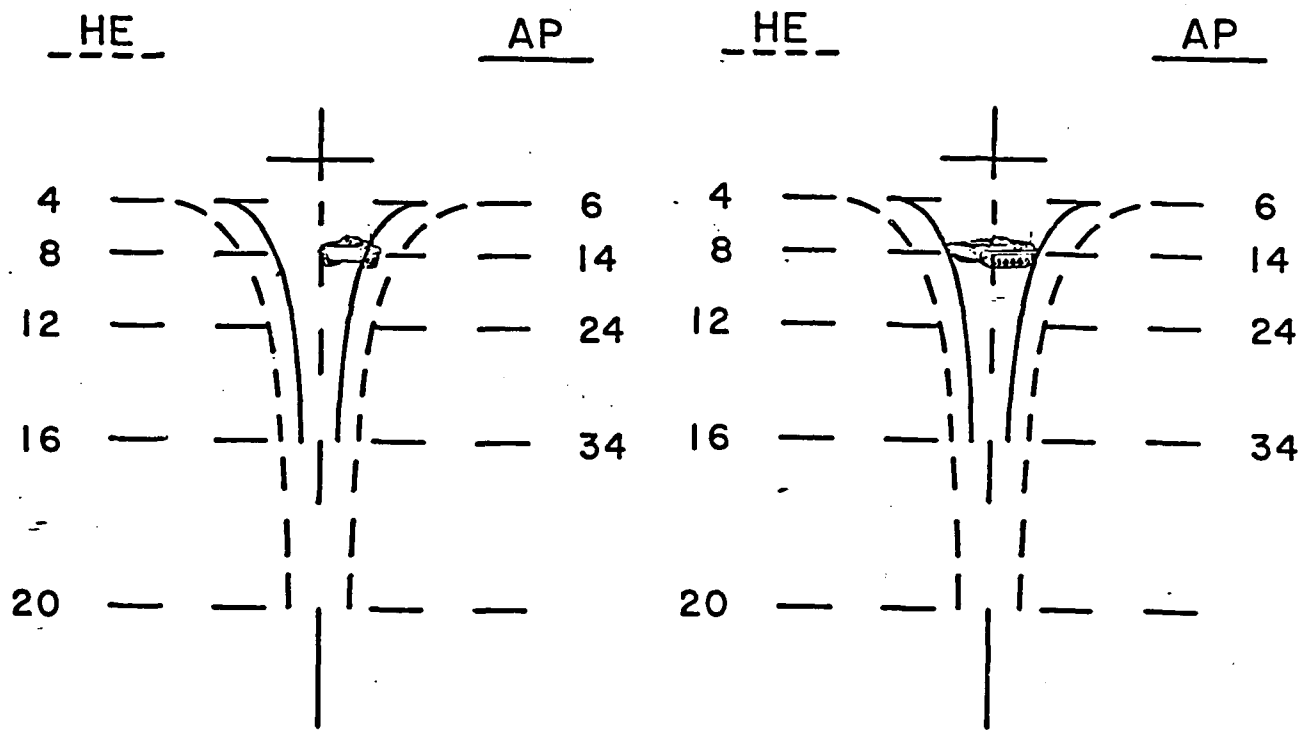
Predicted Percentage of Error in Range Estimation for Flank Angles of a BMP

| Target angle | Technique (part of target measured-representative target size used) | |
|---|---|---|
| | Flank only-Flank (6.74 m) | Entire-Flank (6.74 m) |
| 26 | 128 | 20 |
| 30 | 100 | 14 |
| 34 | 79 | 8 |
| 38 | 62 | 4 |
| 42 | 49 | 1 |
| 46 | 39 | -2 |
| 50 | 31 | -4 |
| 54 | 24 | -6 |
| 58 | 18 | -7 |
| 62 | 13 | -8 |
| 66 | 9 | -8 |
| 70 | 6 | -8 |
| 74 | 4 | -8 |
| 78 | 2 | -6 |
| 82 | 1 | -5 |
| 86 | 0 | -3 |
| 90 | 0 | 0 |



FRONTAL (1.5 MILS) FLANK (2.5 MILS)

Figure 5. Measuring target width with the ISU gun reticle for frontal and flank views of a BMP.




FRONTAL FLANK

Figure 6. Estimating the range to frontal and flank views of a BMP with the ranging stadia of the auxiliary sight unit.

## The Modified Quick Reference Table

Use of the quick reference table for range estimation is intended for long-range observation and surveillance in addition to use in overwatch and defensive positions when time permits. To use the table, the gunner must determine whether a vehicular target belongs to Group I, II or III. A prime target is the BMP which has an actual front (2.94 meters) and side (6.74 meters) width that is intermediate to the front and flank dimensions listed for Groups I (primarily personnel carriers) and II (tanks) of the table (see Figure 1).

The requirement to have both Groups I and II in the table does not seem necessary for two reasons. Firstly, it will be difficult to distinguish many of the vehicles in Groups I and II at long target ranges. Secondly, there is very little difference in the visible total width (mils) of targets in Groups I and II for target ranges beyond 2200 meters (see Table 4). The typical difference in visible total width of Group I and II targets at 2200 meters or longer was 0.1 to 0.3 mils which is beyond the measuring capabilities of the soldier given the design of available reticles.

As shown in Figure 7, the current quick reference table was modified so that targets in Groups I and II would be combined into a single group called Group I. The dimensions of this modified group are 3 meters for the front and 6.75 meters for the side which are very similar to the measurements of a BMP, and yet intermediate to the values used in the original Groups I and II.

NOTE: This table is a quick reference for determining the range of Threat vehicles at various ranges. The vehicles have been grouped and the sizes of the vehicles have been averaged.

**GP 1 (BMP, TANK, BTR, ZSU, OT, MT-LB & TAB)**

| TARGET WIDTH (MILS) | 5 | 4.5 | 4 | 3.5 | 3 | 2.5 | 2 | 1.5 | 1 |
|---|---|---|---|---|---|---|---|---|---|
| FLANK 6.75 METERS | 1400 | 1600 | 1800 | 2000 | 2300 | 2800 | 3400 | 4600 | 6900 |
| FRONT 3.0 METERS | 600 | 700 | 800 | 900 | 1000 | 1200 | 1600 | 2000 | 3000 |

**GP 2 (BMD & BRDM)**

| TARGET WIDTH (MILS) | 5 | 4.5 | 4 | 3.5 | 3 | 2.5 | 2 | 1.5 | 1 |
|---|---|---|---|---|---|---|---|---|---|
| FLANK 5.5 METERS | 1200 | 1300 | 1400 | 1600 | 1800 | 2200 | 2800 | 3800 | 5500 |
| FRONT 2.35 METERS | 400 | 500 | 600 | 700 | 800 | 1000 | 1200 | 1600 | 2400 |

**GP 3 (HIND-D HELICOPTER)**

| TARGET WIDTH (MILS) | 22.5 | 20 | 17.5 | 15 | 12.5 | 10 | 7.5 | 5 | 2.5 |
|---|---|---|---|---|---|---|---|---|---|
| FLANK 17.25 METERS | 800 | 900 | 1000 | 1200 | 1400 | 1800 | 2400 | 3600 | 7000 |

| TARGET WIDTH (MILS) | 5 | 4.5 | 4 | 3.5 | 3 | 2.5 | 2 | 1.5 | 1 |
|---|---|---|---|---|---|---|---|---|---|
| FRONT 6.9 METERS | 1400 | 1600 | 1800 | 2000 | 2400 | 2800 | 3600 | 4600 | 6900 |

Figure 7. Modified quick reference table.

The quick reference table was modified to eliminate zero scores. In addition, Group III (formerly IV) was modified for flank views. The measurement interval was increased from 1 to 2.5 mils (the ISU reticle is marked in 2.5 mil intervals) because of the large size of a flank view of a helicopter.

## Use of the TV-Technique for Moving Target Engagements

There are three aiming rules for engaging moving vehicular targets with the 25-mm gun from a stationary BFV. The gunner aims (a) center base of visible mass when the target is moving toward him, (b) top center of visible mass when the target is fleeing, and (c) with a 2.5-mil lead from target center of mass if the target is moving perpendicular to the gun (FM 23-1, 1986). However, there is no criterion for determining direction/angle of movement by the target.

A separate analysis (Perkins, 1988a) examined the effect of angle of approach by the target on aiming requirements. Based on that analysis, it was recommended that the lead rule be applied on a flank view of a moving target. When armor-piercing (AP) ammunition is used, the recommended lead is 5-mils from target center of mass (see Figure 8). Lead would not be applied on a frontal or rear view (rear of target appears larger than the side) of the target.

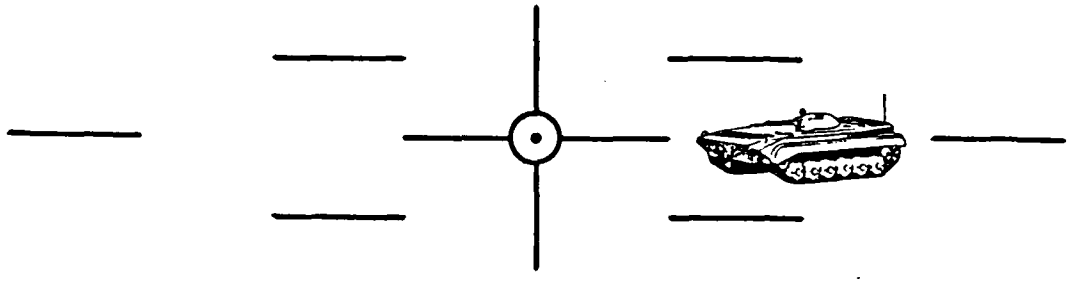


Figure 8. Lead applied on a flank view of a moving BMP engaged with AP ammunition.

Table 4

Visible Total Width (mils) of Target Groups in the Quick Reference Table

| Range (meters) | Target group | Target angle (degrees) 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1000 | 1 | 2.9 | 4.0 | 5.1 | 6.0 | 6.8 | 7.3 | 7.6 | 7.7 | 7.5 | 7.1 |
| | 2 | 3.4 | 4.5 | 5.5 | 6.3 | 6.9 | 7.3 | 7.4 | 7.4 | 7.1 | 6.6 |
| | 3 | 2.4 | 3.3 | 4.2 | 4.9 | 5.4 | 5.8 | 6.0 | 6.1 | 5.9 | 5.6 |
| 1600 | 1 | 1.8 | 2.5 | 3.2 | 3.8 | 4.2 | 4.6 | 4.8 | 4.8 | 4.7 | 4.5 |
| | 2 | 2.1 | 2.8 | 3.4 | 3.9 | 4.3 | 4.5 | 4.6 | 4.6 | 4.4 | 4.1 |
| | 3 | 1.5 | 2.1 | 2.6 | 3.0 | 3.4 | 3.6 | 3.8 | 3.8 | 3.7 | 3.5 |
| 2200 | 1 | 1.3 | 1.8 | 2.3 | 2.7 | 3.1 | 3.3 | 3.5 | 3.5 | 3.4 | 3.2 |
| | 2 | 1.6 | 2.1 | 2.5 | 2.8 | 3.1 | 3.3 | 3.4 | 3.4 | 3.2 | 3.0 |
| | 3 | 1.1 | 1.5 | 1.9 | 2.2 | 2.5 | 2.7 | 2.7 | 2.8 | 2.7 | 2.5 |
| 2800 | 1 | 1.0 | 1.4 | 1.8 | 2.2 | 2.4 | 2.6 | 2.7 | 2.7 | 2.7 | 2.5 |
| | 2 | 1.2 | 1.6 | 2.0 | 2.2 | 2.5 | 2.6 | 2.7 | 2.6 | 2.5 | 2.4 |
| | 3 | 0.9 | 1.2 | 1.5 | 1.7 | 1.9 | 2.1 | 2.2 | 2.2 | 2.1 | 2.0 |
| 3400 | 1 | 0.8 | 1.2 | 1.5 | 1.8 | 2.0 | 2.1 | 2.2 | 2.3 | 2.2 | 2.1 |
| | 2 | 1.0 | 1.3 | 1.6 | 1.8 | 2.0 | 2.1 | 2.2 | 2.2 | 2.1 | 1.9 |
| | 3 | 0.7 | 1.0 | 1.2 | 1.4 | 1.6 | 1.7 | 1.8 | 1.8 | 1.7 | 1.6 |
| 4000 | 1 | 0.7 | 1.0 | 1.3 | 1.5 | 1.7 | 1.8 | 1.9 | 1.9 | 1.9 | 1.8 |
| | 2 | 0.9 | 1.1 | 1.4 | 1.6 | 1.7 | 1.8 | 1.9 | 1.8 | 1.8 | 1.7 |
| | 3 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.5 | 1.5 | 1.5 | 1.5 | 1.4 |
| 4600 | 1 | 0.6 | 0.9 | 1.1 | 1.3 | 1.5 | 1.6 | 1.7 | 1.7 | 1.6 | 1.6 |
| | 2 | 0.7 | 1.0 | 1.2 | 1.4 | 1.5 | 1.6 | 1.6 | 1.6 | 1.5 | 1.4 |
| | 3 | 0.5 | 0.7 | 0.9 | 1.1 | 1.2 | 1.3 | 1.3 | 1.3 | 1.3 | 1.2 |
| 5200 | 1 | 0.5 | 0.8 | 1.0 | 1.2 | 1.3 | 1.4 | 1.5 | 1.5 | 1.4 | 1.4 |
| | 2 | 0.7 | 0.9 | 1.1 | 1.2 | 1.3 | 1.4 | 1.4 | 1.4 | 1.4 | 1.3 |
| | 3 | 0.5 | 0.6 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 | 1.2 | 1.1 | 1.1 |
| 5800 | 1 | 0.5 | 0.7 | 0.9 | 1.0 | 1.2 | 1.3 | 1.3 | 1.3 | 1.3 | 1.2 |
| | 2 | 0.6 | 0.8 | 0.9 | 1.1 | 1.2 | 1.3 | 1.3 | 1.3 | 1.2 | 1.1 |
| | 3 | 0.4 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 6400 | 1 | 0.4 | 0.6 | 0.8 | 0.9 | 1.1 | 1.1 | 1.2 | 1.2 | 1.2 | 1.1 |
| | 2 | 0.5 | 0.7 | 0.9 | 1.0 | 1.1 | 1.1 | 1.2 | 1.2 | 1.1 | 1.0 |
| | 3 | 0.4 | 0.5 | 0.7 | 0.8 | 0.8 | 0.9 | 0.9 | 1.0 | 0.9 | 0.9 |
| 7000 | 1 | 0.4 | 0.6 | 0.7 | 0.9 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.0 |
| | 2 | 0.5 | 0.6 | 0.8 | 0.9 | 1.0 | 1.0 | 1.1 | 1.1 | 1.0 | 0.9 |
| | 3 | 0.3 | 0.5 | 0.6 | 0.7 | 0.8 | 0.8 | 0.9 | 0.9 | 0.8 | 0.8 |

## Summary and Conclusions

The BFV Gunnery field manual (FM 23-1, 1983; 1986) indicates three tasks that require classification of a vehicular target as a frontal or flank view: (a) use of the quick reference table for range estimation, (b) use of the ranging stadia of the auxiliary sight unit, and (c) application of lead rules on a target moving perpendicular to the line of fire of the 25-mm gun. This report describes the development of the TV-technique to classify a target as either a frontal or flank view. Descriptively, the front of the vehicle appears larger than the side for a frontal view while the side appears larger than the front for a flank view (see Figure 4).

Classifying a target view as frontal or flank is necessary when using the quick reference table for range estimation (see Figure 1). The current table has three categories for vehicular targets. Two of the groups (I and II) represent the majority of target types (personnel carriers and tanks) engaged by the BFV. In that there are minimal differences in the visual size of targets in these two groups for ranges beyond 2000 meters, the table was modified so that Group I had target dimensions that are intermediate to targets in Groups I and II in the current table. The dimensions of the modified Group I target are similar to those of a BMP.

While the recommended quick reference table was modified (see Figure 7) to facilitate range estimation of long range targets, the table also is useful for range estimation when engaging BMP-sized targets. Target angle will affect ranging accuracy, but in general, use of the ISU gun reticle to measure target size should allow about 100-meter accuracy for ranges between tracer burn out (i.e., 1700 meters) and effective battlesight ranges for AP ammunition.

When using the modified quick reference table, it is recommended that target size is measured using the ISU gun reticle instead of the reticle of binoculars. The ISU reticle provides greater ranging accuracy than the binoculars because of higher magnification, more frequent mil-markings, and a more stable platform for measuring target width.

Classification of target view also can be used for engaging moving targets. The lead-rule should be applied if the target is classified as a flank view. If the target is a frontal view, then the aiming point would be that recommended for a target moving toward the BFV (see FM 23-1).

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